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ANOPHELES (NYSSORHYNCHUS) KONDERI GALVÃO AND DAMASCENO: NEOTYPE DESIGNATION AND RESURRECTION FROM SYNONYMY WITH *ANOPHELES (NYSSORHYNCHUS) OSWALDOI* (PERYASSU) (DIPTERA:CULICIDAE)

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Abstract.—*Anopheles* (*Nyssorhynchus*) *konderi* Galvão and Damasceno 1942 is redescribed with illustrations of the male and female genitalia and the larval and pupal stages. A neotype for *An. konderi* is designated, and it is resurrected from synonymy with *An.* (*Nys.*) *oswaldoi* (Peryassu 1922).

Key Words: *Anopheles konderi, Anopheles,* Culicidae, taxonomy, redescription, malaria

Anopheles (*Nyssorhynchus*) *konderi* Galvão and Damasceno 1942 is similar to *An. oswaldoi* (Peryassu 1922) in larval, pupal and adult female characters, being distinguished by only one character in the male genitalia. During the 1940's, several authors considered *An. konderi* and *An. oswaldoi* as distinct species and made contributions to the knowledge of their geographical distribution and biology (Causey et al. 1946; Coutinho 1946; Deane et al. 1946, 1948). However, Lane (1953) considered *An. konderi* a synonym of *An. oswaldoi* and this concept was widely accepted. Indeed, the last revisions of *Anopheles* subgenus *Nyssorhynchus* (Faran 1980, Faran and Linthicum 1981) agreed with Lane (1953). E.L. Peyton (*apud* Klein and Lima 1990) observed differences in the behavior and malaria transmission potential of material collected in Costa Marques, Brazil. He suggested the existence of two forms of *An. oswaldoi*: one was present in recently modified open areas (*An. konderi*), and another restricted to forested areas (*An. oswaldoi*). Although the species has never been formally resurrected from synonymy with *An. oswaldoi* or morphologically well characterized in all stages, the name *An. konderi* has appeared in papers since Peyton's statement (Lounibos et al. 1997, Marrelli et al. 1999).

In the present paper, morphological and morphometric analyses of specimens of *An. konderi* and *An. oswaldoi* were conducted to distinguish these species and to redescribe the former.

MATERIALS AND METHODS

Progenies of females and immature stages of *An. oswaldoi s.l.* collected in six localities in Brazil and one in Peru were included in the present study. To obtain progenies, females were blood fed and kept in individual oviposition vials. Some eggs from each female were fixed and stored in

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4% glutaraldehyde or alcoholic Bouin's solution for morphological analyses.

We follow the terminology of Harbach and Knight (1980) for morphological features and Wilkerson and Peyton (1990) for wing spot nomenclature. Abbreviations used are as follows: M, male; F, female; G, genitalia; Le, larval exuviae; Pe, pupal exuviae. The nomenclature adopted for the dorsal and ventral polarities of eggs is that of Clements (1992) and Valle et al. (1999), which is opposite of classical studies on the external morphology of the egg. The polarity is determined in the maternal organism during ovular development: the flat side of the egg or deck is considered the dorsal side and the submerged convex inferior side is ventral.

Statistical analysis of morphometric characters was done using the Kruskal-Wallis test to verify the existence of significant differences among the samples of *An. konderi* from different localities. When morphometric characters were homogeneous between samples of *An. konderi,* they were subsequently compared with those in *An. oswaldoi,* using the Mann-Whitney test. Both the Kruskal-Wallis and the Mann-Whitney tests were done using the SPSS–Windows program version 8.0 (SPSS, Chicago), at a 5% significance level.

The characters and ratios used for statistical analysis were: *Female:* Length of the wing, basal dark spots on hindtarsomere II, length of maxillary palpus/forefemur, total length of palpomere 3/size of basal white scaling on the same segment, proportion of basal dark-scaled band on fore- and midtarsomeres II and III, length of humeral pale spot/prehumeral dark, length of subcostal pale/sector dark, length of preapical pale/preapical dark, length of apical dark/preapical pale and percentage of specimens with divided sector dark spot. *Male:* Length of the wing, basal dark spot on hindtarsomere II, ratio of length of parabasal seta/width of gonocoxite at base, length of the aedeagus/length of claspette; length/width of sternum VIII (measured at base), length of gonocoxite/width of gonocoxite at base, width of gonocoxite taken at the widest point/width of gonocoxite at base. *Pupa:* Length of meatus/length of trumpet, trumpet index (length trumpet/width trumpet), length of tracheoid/length of trumpet; length of seta 1-IV/length tergum V, and paddle index (length of paddle/width of paddle measured at the widest point). *Larva:* Clypeal index (distance between insertion of seta 3-C on one side/distance between insertions of setae 2-C), length of antenna/distance between base of antenna and insertion of seta 1-A, length of anal papilla/length of seta 4-X, distance between apices of lateral arms of median plate of spiracular apparatus/distance between spiracular opening (SO_p), percentage of specimens with seta 1-X borne on saddle, type of pecten, and number of pecten spines. The type of pecten was classified according to a formula, in which numbers were given to represent the size of spines: "0" for short spines, "1" for medium size spines (about twice as long as short spines "0") and "2" for large and long spines (about three times as long as spine "0").

Taxonomic Treatment

Anopheles (Nyssorhynchus) konderi Galvão and Damasceno

Anopheles (Nyssorhynchus) konderi Galvão and Damasceno 1942: 115–118, 132–133. Type: Holotype male, right (south) margin of Rio Solimões, Coari, State of Amazonas, Brazil (Departamento de Parasitologia da Faculdade de Medicina de Universidade de São Paulo, S.P., Brasil), lost (Belkin et al. 1971). Galvão 1943: 156; Causey et al. 1946: 12; Coutinho 1946: 72; Deane et al. 1946: 27; Deane et al. 1948: 876; Lounibos et al. 1997: 148.

Female (Figs. 1A, B, C).—*Head:* Integument darkish brown. Interocular space with approximately 20 white long semi-decumbent fusiform scales. Vertex with numerous white erect spatulate scales. Occiput

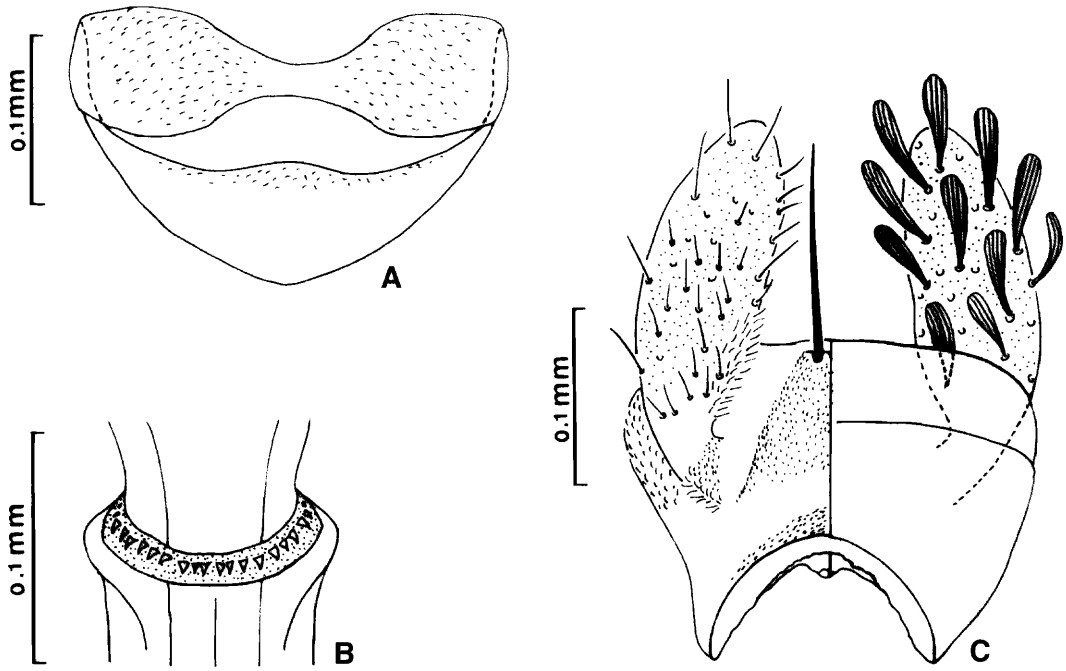

Fig. 1. *Anopheles konderi*. A, Abdominal segment X of male. B, Female cibarium. C, Female cerci. Coari, Amazonas, Brazil.

and postgena with brown erect, spatulate scales. Postgena with elongate setae, few white spatulate scales at junction of eyes; ocular setae (8–12) long, brown. Clypeus brown, bare. Antenna: flagellum (1.14 mm) with 13 flagellomeres with darkish integument and dirty white pollinosity, flagellar whorls pale; flagellomere 1 with decumbent white scales, and distal surface with patch of white falcate scales dorsally. Pedicel integument brown, with small patch of white decumbent scales dorsally. Proboscis 1.5–2.7 mm (mean = 2.1 mm), integument dark brown; proximal third with brown erect scales, remainder covered by darkish brown decumbent scales. Proboscis nearly 1.0 (0.8–1.0) length of maxillary palpus. Labial basal setae 8, brown. Labellum brown, paler than proboscis, pollinose. Maxillary palpus 1.7–2.7 mm (mean = 2.1 mm), integument dark, covered with darkish narrow spatulate scales, 1.4 [(1.1–1.8) ± 0.14, P = 0.03] [mean (range) ± standard error of the mean, P] of forefemur; palpomere 1 length 0.14–0.21 mm (mean = 0.17 mm) covered with brown spatulate scales; palpomere 2 length 0.27–0.4 mm (mean = 0.43 mm), covered with dark scales, dorsally sprinkled with few (7,8) white scales, and with apical narrow band of white scales; palpomere 3, length 0.64–0.94 mm (mean = 0.81 mm), almost completely dark, dark-scaled area 4.8 [(2.8–8.7) ± 1.64, P = 1.64] times white-scaled area; palpomere 4 length 0.43–0.65 mm (mean = 0.5 mm), white-scaled dorsally, with narrow dark bands at ends; palpomere 5 length 0.22–0.31 mm (mean = 0.26 mm), completely white; ventral surface of palpomeres 1–4 dark-scaled. Cibarium (Fig. 1B) with 17 (14–21) cibarial teeth of variable form and size. *Thorax:* Scutum length approximately 1.0 mm; integument darkish brown with pale scales and pollinosity; setae yellowish brown, numerous; integument mottled with 3 dark spots: 2 near scutal fossa and 1 on prescutellar area. Anterior promontory with white linear, erect scales. Antealar scales white,

elongate and spatulate. Scutellum covered with small falcate grayish scales; scutellar setae brown, about 13 (11–15) long and 4 (4–9) short, distributed along caudal margin. Antepronotum with spatulate, erect, brown scales, few pale scales basally; setae short, brown. Pleural integument brown to darkish brown. Usually 4 bronze upper mesokatepisternal setae, about 7 (3–7) white upper mesokatepisternal scales, 1 brown lower mesokatepisternal seta, 2,3 white mesokatepisternal scales, prealar scales and setae pale; about 3 yellowish upper mesepimeral setae, lower mesepimeral scales absent; upper proepisternal setae bronzy, thin and short; 2 brown lower proepisternal setae. *Legs:* Integument dark. Coxae: Anterior surface of forecoxa with patch of white scales, ventral 0.5 with brownish scales, 2–4 brown setae; anterior surface of mid- and hindcoxae with pale scales transversally. Trochanters with patch of white scales, setae long and brown. Femora, tibiae and tarsi essentially dark-scaled, broadly pale grayish or light cream scales on ventral surfaces. Femora and tibiae scattered with light cream scales dorsally, principally on fore- and midlegs. Foreleg: Femur length 1.28–1.62 mm (mean = 1.45 mm); tibia, length 1.68–2.05 mm (mean = 1.86 mm); tarsomere 1, length 1.0–1.34 mm (mean = 1.18 mm) with narrow band (mean = 0.04 of tarsomere) of white scales distally; tarsomere 2, length 0.4–0.6 mm (mean = 0.5 mm) dark-scaled on basal 0.7 [(0.5–0.9) ± 0.09, P = 0.128]; tarsomere 3, length 0.2–0.5 mm (mean = 0.3 mm), dark-scaled on basal 0.3 [(0.1–0.6) ± 0.14, P = 0], remainder white; tarsomere 4, length 0.17–0.26 mm (mean = 0.21 mm), completely dark-scaled, rarely with pale scales distally; tarsomere 5, length 0.14–0.2 mm (mean = 0.17 mm), dirty white, with ring of dark scales on basal 0.41. Midleg: Femur dark, length 1.54–2.08 mm (mean = 1.74 mm), with narrow band of white scales at base; tibia dark, length 1.8–2.37 mm (mean = 1.9 mm), with few pale spines at apex; tarsomere 1 dark, length 1.2–1.7 mm (mean = 1.43 mm), with small band of white scales distally (0.04 of tarsomere); tarsomere 2, length 0.5–0.8 mm (mean = 0.66 mm), dark-scaled on basal 0.9 [(0.7–1) ± 0.06, P = 0.69]; tarsomere 3, length 0.3–0.7 mm (mean = 0.5 mm), usually completely dark (0.9 [0.7–1] ± 0.04, P = 0.45), dark-scaled, with sparse pale scales distally; tarsomere 4, length 0.29–0.34 mm (mean = 0.29 mm) usually all dark-scaled, with rare pale scales distally; tarsomere 5, length 0.17–0.21 mm (mean = 0.18 mm), dark-scaled on basal 0.4, remainder white. Hindleg: Femur, length 1.5–2.1 mm (mean = 1.7 mm), with 2 distal strong yellowish setae; tibia, length 1.7–2.5 mm (mean = 2.0 mm), with small ring of white scales distally; tarsomere 1, length 2.34–2.66 mm (mean = 2.63 mm), with narrow ring of white scales distally; tarsomere 2, length 0.63–0.89 mm (mean = 0.76 mm), dark-scaled on basal 0.14 [(0.08–0.20) ± 0.036, P = 0.23], remainder white; tarsomeres 3 and 4 white, tarsomere 3, length 0.4–0.69 mm (mean = 0.58 mm); tarsomere 4, length 0.31–0.48 mm (mean = 0.41 mm); tarsomere 5, length 0.26–0.34 mm (mean = 0.26 mm), dark-scaled on basal 0.5. *Wings:* Length 3.0–4.0 mm (mean = 3.4 mm ± 0.207, P = 0.27), pale wing spots white, dark spots darkish brown to black. Basal pale spot plus prehumeral pale spot large, length 0.24 mm (0.20–0.26 mm), more than 2.5 of prehumeral dark; basal dark spot absent; humeral pale spot 3.6 [(1.2–9.0) ± 1.41, P = 0.19] of prehumeral dark; subcostal pale spot 0.2 [(0–0.4) ± 0.09, P = 0.302] of sector dark; preapical pale spot (PP) 0.3 [(0–0.5) ± 0.09, P = 0.38] of preapical dark (PD); apical dark spot 0.4 [(0.1–1) ± 0.69, P = 0.684] of PP; accessory sector dark present in 82.4% (± 0.921, P = 0.65) of specimens examined. Size of dark spots on Costa varying within progenies and between populations (n = 51). Veins CuA, M_{3+4}, M_{1+2}, M_1, M_2 and 1A covered with sparse thin fusiform scales; veins R_{2+3}, R_2, R_3 and R_{4+5} densely covered with linear scales. Vein R_1 with 4,5 (5) dark spots. R_s+R_{2+3} with 1–3

(2) dark spots; when only 1 dark spot present it occupies more than 0.7 of vein; when 2 dark spots present, basal white spot smaller than distal one. R_2 with 1–3 (2) dark spots; when 2 dark spots present, apical spot smaller; R_3 with 1–3 (2) dark spots; most frequently with 2 small spots, proximal spot smaller than distal one; R_{4+5} with 2 small dark spots, 1 basal and other distal. M_{1+2} with 1–3 dark spots, more frequently with 2 dark spots; when only 1 dark spot present it occupies more than 0.7 of vein, ventral surface of M_{1+2} covered with dark scales. M_1 with 1,2 (2) dark spots, sometimes sprinkled with white scales; M_2 with 1,2 (1) dark spots. M_{3+4} with 3 small dark spots. CuA with 1 small dark spot distally; 1A with 2 dark spots; CuP with 1 small distal dark spot. R_{4+5} separating from R_{2+3} on level of distal 0.33 of sector dark spot. M_{3+4} 0.33 longer than CuP. Cell R_2 0.7 of cell M_1. Cell M_1 0.5 of M_{1+2}. Remigium with integument pale. *Halter:* Length 0.35 mm; integument of scabellum, pedicel and ventral surface of capitellum pale, remainder of capitellum and distal 0.35 of pedicel dark. *Abdomen:* Integument dark brown, pollinosity grayish, scales falcate. Terga: tergum I with abundant brown setae; terga II–VII with posterolateral tufts of broad erect spatulate dark scales and distal median patches of grayish to cream scales in roughly triangular shape; tergum VIII covered with abundant cream scales; posterolateral setae numerous and long. Sterna with few brown setae; sternum I without white scales; sterna II–VII with white, spatulate scales laterally; posteromedian area with patch of spatulate brown scales. Sternum VIII length/width = 1.0 (0.5–1.5). *Genitalia* (Fig. 1C): Sternum IX, length/width = 0.6 (0.2–1.0); cercus elongate, with spatulate brown scales dorsally, and dark scales and setae ventrally; 2 postgenital setae, inserted close together, strong, length 6.2 (4.6–10) distance between them; postgenital setae generally slightly smaller than cercus, length of postgenital seta/length of cercus = 0.7 (0.5–1.0); insula bare.

Male (Figs. 2D, E, F).—Similar to female except for sexual and few other differences as follow. *Head:* Interocular space with about 20–26 long white setae. Antenna strongly verticilate, length 1.5–1.9 mm (mean = 1.7 mm), flagellomeres with integument grayish, heavily plumose, setae long and pale. Proboscis length 1.9–2.4 mm (mean = 2.2 mm), maxillary palpus 1.0 (0.9–1.0) length of proboscis. Maxillary palpus: palpomere 1 as in female; palpomeres 2 and 3 with one narrow band of white scales distally, palpomere 4 white-scaled on dorsal surface, with dark bands of dark scales at ends; setae of different lengths, some developed setae inserted basally surpass palpomere 5; palpomere 5 covered dorsally with pale scales, setae pale and dark; palpomeres 4 and 5 expanded, with dark scales on ventral surface. *Thorax:* Lower mesokatespisternal scales (8–10) white. *Legs:* Hindtarsomere 2 dark-scaled on basal 0.15 [(0.10–0.20) ± 0.020, P = 0.054]. *Wing:* Length 3.3 mm [(2.9–3.7 mm) ± 0.21, P = 0.16]; subcostal dark spot 0.4 of sector dark; dark spots on internal veins smaller than in female. *Halter:* Length 0.16–0.27 mm (mean = 0.24 mm). *Abdomen:* Sternum VIII roughly trapezoidal in shape, moderately elongate, ratio length/width = 0.8 [(0.1–1.3) ± 0.14, P = 0.11]. *Genitalia:* (Fig. 2D, E, F). Lobes of sternum IX as wide as long, length 0.65 mm (0.4–0.8 mm). Parabasal seta 0.8 [(0.5–1.6) ± 0.14, P = 0.01] width of gonocoxite. Gonocoxite elongate, length 3.3 [(1.7–4.7) ± 0.66, P = 0.009] width at base, expanded on basal 0.5 [width 1.5 (1.0–2.1) ± 0.26, P = 0 width at base], outer surface strongly convex, inner surface concave, long setae on tergal surface extending to ventrolateral surface. Ventrolateral surface with numerous long spatulate scales, dorsomesal surface with narrow linear patch of small, short setae. Gonostylus moderately shorter than gonocoxite, length (0.85) of gonocoxite, strongly curved, with internal spicules beyond middle; gonostylar claw spiniform and blunt. Ventral lobe of claspette with

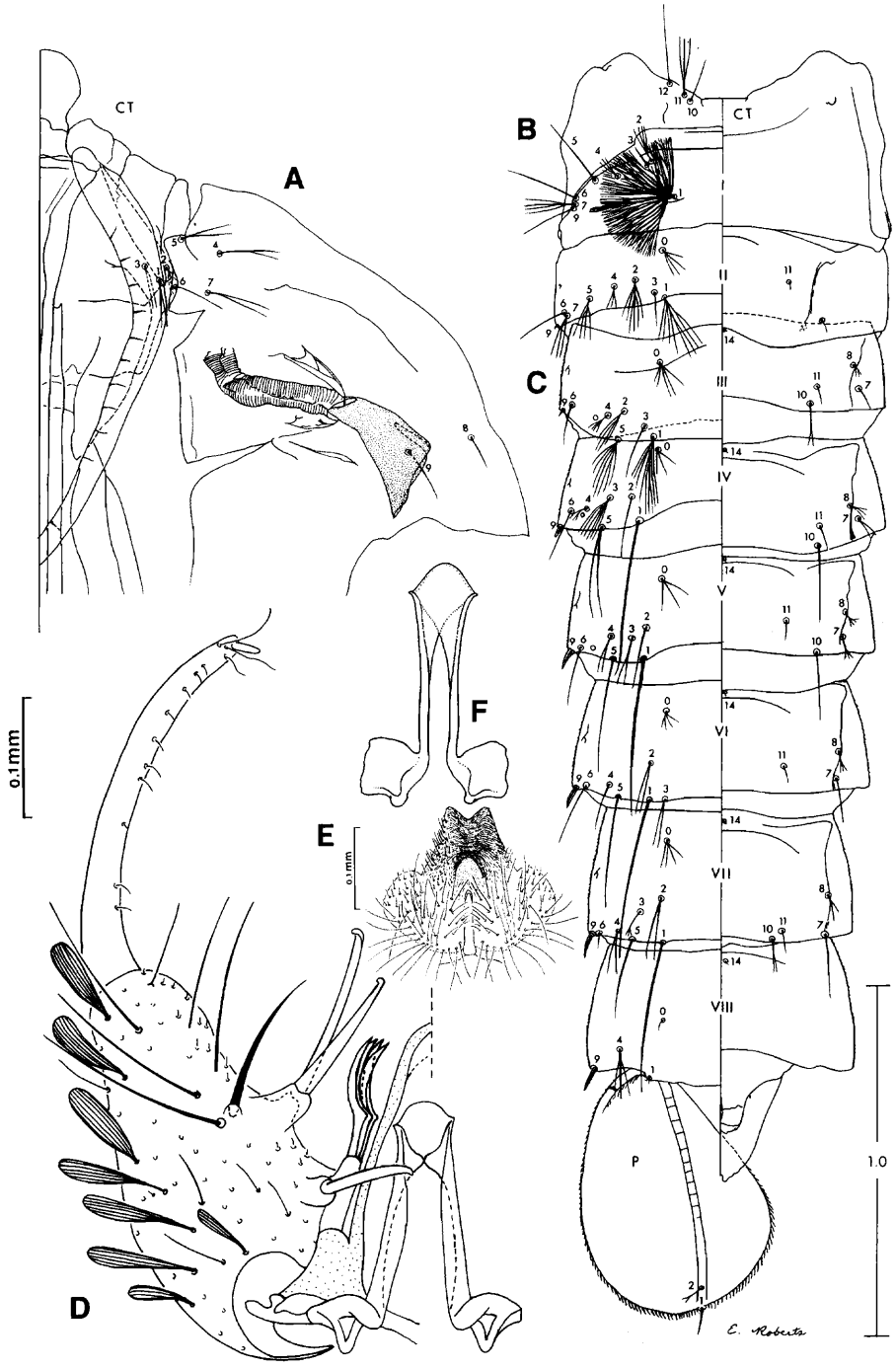

Fig. 2. *Anopheles konderi* (drawn from specimens BR103(5)-1, BR095(1)-2, and BR097(2)-17, Costa Marques, Brazil). A–C, Pupa. A, Cephalotorax. B, Metathorax. C, Abdominal segments. D–F, Male. D, Male genitalia. E, Ventral lobe of claspette. F, Aedeagus.

apical lobe moderately sclerotized, narrow, lobe length 3 times its width at base, with conspicuous median sulcus; refringent structure moderate in size; setae short and strong; basal lobule expanded laterally, with numerous long and strong setae distributed along basal margin. Dorsal lobe of claspette with pedicel moderately narrow, apex round, narrower than base, apex with 3,4 moderately broad leaflets. *Phallosome:* Aedeagus length 1.3 [(1.0–1.6) ± 0.21, P = 0.104] length of claspette; weakly rounded at apex, length of apex of aedeagus about 0.4 (0.3–0.6) of width, apical aedeagal sclerite narrow and curved in elbow-like lateral projections. Paraproct weakly sclerotized, narrow distally and expanded at base.

Pupa (Fig. 2A, B, C).—Position and development of setae as figured; range and modal number of branches in Table 1. Integument brown, sclerotized. *Cephalothorax:* Integument more pigmented than abdomen. Trumpet: length 0.63 mm (0.52–0.9 mm), laticorn, pigmented and spiculose, tragus elaborate, trumpet index 2.3 [(1.6–5.7) ± 0.06, $P < 0.0001$], meatus length 0.2 [(0.1–0.4) ± 1.36, $P = 0.53$] of trumpet length; pinna 0.12–0.28 mm (mean = 0.21 mm); tracheoid length 0.4 [(0.2–0.7) ± 0.40, $P = 0.4$] of the trumpet length. *Abdomen:* Seta 1-IV strongly sclerotized, length 0.35–0.55 mm (mean = 0.46 ± 0.06); seta 1-IV moderately developed, 1.6 (1.1–2.2) length of tergum V; tergum V length 0.23–0.39 mm (mean = 0.29 mm); seta 9-II minute; 9-III–VIII thick, short, dark brown. Paddle: pale, slightly paler than abdomen, ovate, slightly longer than wide, index 1.1–1.7 (1.4) ± 0.24; external margin spiculose, paddle marginal spicules more developed on distal 0.5; midrib distinct.

Larva (Fig. 3).—Position and development of setae as in Fig. 3; range and modal number of branches in Table 2. *Head:* Integument pale, collar strongly pigmented. Antenna: length 1.0 mm (0.93–1.17 mm), antenna length 4.9 [(2.8–8.5) ± 1.19, P = 0.22] distance from insertion of seta 1-A to base; ventral surface of antenna with short spicules, less numerous distally; seta 1-A inserted 0.2 mm (0.1–0.4 mm) from base of antenna, with 3–10 (5) branches; length of seta 1-A 0.7–1.5 (1.0) times width of antenna at point of insertion; seta 4-A bifurcate; setae 2,3,5,6-A usually tapered at apex; 2,3-A almost same size; 5-A short, half size of 2,3-A, 6-A slightly shorter than 5-A. Setae 2-C widely separated, clypeal index 1.4 (0.8–1.9) ± 0.27; setae 2,3-C almost same size, branched, branches usually dendritic. Ventromentum pale, with 3 teeth on each side of 2 central more developed teeth. Dorsomentum dark, strongly sclerotized, with 4 teeth on each side of one central more developed tooth. *Thorax:* Seta 1-P palmate; 1–3-P arising from distinct tubercles; 11-P single or double, much shorter than 9,10,12-P but much more developed than 1-M,T; 3-T weakly developed, palmate. *Abdomen:* Integument pale. Seta 1-I palmate, with 9–24 (14) moderately developed, weakly pigmented branches; 1-II–VII palmate, leaflets usually broad, well developed and strongly pigmented; 1-X usually inserted outside saddle (86.3% of specimens examined). Saddle incomplete. Anal gills hyaline, length 0.43 mm (0.28–0.63 mm), 0.9 [(0.6–1.4) ± 0.19] length of seta 4-X. Posterior margin of segment X with numerous short spicules. *Spiracular apparatus:* Lateral arms of median plate developed, elongate, projecting toward spiracular process or spiracular opening; distance between apices of lateral arms 1.3 [(0.8–1.8) ± 1.17] of distance between SO_p. Pecten with 16 [(12–20) ± 4.76, P = 0.036] spines. Three types of pecten were found: type I = 2-0-2(n)-0-2(n)-0; type II = 0(n)-2(n)-1-2(n)-0 and Type III = 1(n)-2-0-2(n)-0-2(n)-0. The most common formula was type I [formula = 2-0-2(n)-0-2(n)-0], in which "n" is the variable number of repetitions of a kind of spine in the pecten.

Egg (Fig. 4).—Boat-shaped in both dorsal and lateral views; ventral view almost flat. Length 421 μm (379–520 μm); width

Table 1. Pupal setal branching for *An. konderi:* range (mode), of six Brazilian populations (Coari, Porto Velho, Candeias do Jamari, Senador Guiomar, Sena Madureira and Linhares) and one Peruvian (Yurimaguas).

Seta No.	Cephalothorax	Metanotum	Abdominal Segments								
			I	II	III	IV	V	VI	VII	VIII	Paddle
0	—		—	2–7 (4)	3–7 (4,5)	3–6 (5)	2–6 (4)	3–6 (4)	3–6 (4)	1,2 (1)	—
1	1–4 (1,2)	—	D	4–14 (10)	1–12 (8)	1–9 (1)	1	1	1	1	1
2	1–3 (2)	—	2–7 (5)	1–10 (6)	3–7 (5)	1–5 (2)	1–5 (3)	1–4 (3)	1–4 (3)	—	1,2 (2)
3	1–4 (3)	—	1,2 (1)	1	1–3 (1)	1–6 (4)	1–6 (3)	1–4 (2)	1–5 (4)	—	—
4	1–4 (3)	—	3–7 (4)	1–7 (4)	1–4 (2)	1–5 (2)	2–5 (3)	1–4 (2)	1–3 (2)	2–5 (4)	—
5	1–3 (2)	—	1–3 (2)	1–7 (4)	3–10 (8)	1–8 (3)	1–4 (1)	1–3 (1)	1,2 (1)	—	—
6	1–4 (1)	—	1,2 (1)	1,2 (1)	1–3 (1)	1–3 (1)	1,2 (1)	1–3 (1)	1,2 (1)	—	—
7	1–3 (3)	—	1–5 (2)	1–8 (2)	1–4 (2)	1–4 (2)	1–4 (2)	1–3 (1)	1,2	—	—
8	1	—	—	—	1–4 (3)	1–4 (2)	1–4 (2)	1–3 (2)	1–5 (3)	—	—
9	1–3 (2)	—	1	1	1	1	1	1	1	1	—
10	—	1,2 (1)	—	—	1–4 (3)	1–3 (1)	1–3 (1)	—	1–3 (2)	—	—
11	—	2–5 (4)	—	1	1–3 (1)	1,2 (1)	1,2 (1)	1,2 (1)	1–3 (1)	—	—
12	—	1–3 (1)	—	—	—	—	—	—	—	—	—
13	—	—	—	—	—	—	—	—	—	—	—
14	—	—	—	—	1	1	1	1	1	1	—

D = dendritic

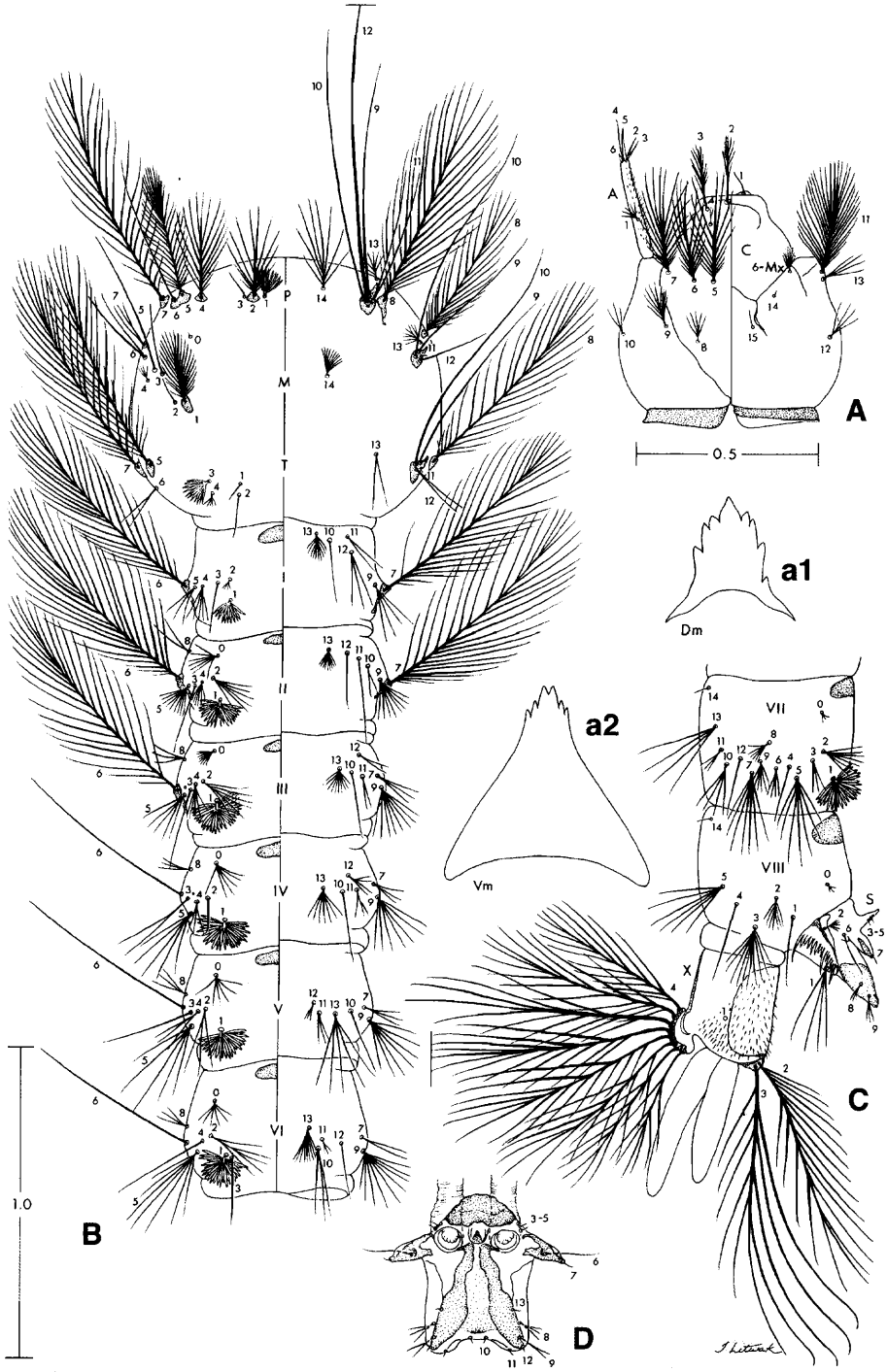

Fig. 3. *Anopheles konderi*, larva (drawn from specimens BR097(2)-10 and BR097(2)-8, Costa Marques, Brazil). A, Head, a1—dorsomentum, a2—ventromentum. B, Thorax and abdominal segments I–VI. C, Abdominal segments VII–X. D, Spiracular apparatus. Scales in mm.

Table 2. Larval setal branching for *An. konderi:* range (mode), of six Brazilian (Coari, Porto Velho, Candeias do Jamari, Senador Guiomar and Linhares) and one Peruvian population (Yurimanguas).

Seta No.	Head	Ant.	Thorax			Abdominal Segments									
			P	M	T	I	II	III	IV	V	VI	VII	VIII	Spiracular Apparatus	X
0	1	—	1	—	—	—	3–10(4)	3–8(5)	3–8(4)	2–7(5)	3–6(4)	2–6(4)	1–4(3)	—	—
1	1	3–10(5)	9–20(12)	18–32(26)	1	9–24(14)	9–32(20)	10–32(24)	10–36(28)	13–32(23)	15–31(24)	10–28(22)	1,2(1)	3–8(5)	1
2	3–12(5–7)	1	9–21(12–14)	1	1	2–7(4)	3–8(6)	2–8(3)	1	1–4(3)	3–8(5)	3–11(5)	3–12(6)	2–6(3)	P
3	2–13(9)	1	1	1	6–16(12)	1,2(1)	1	1	1–6(3)	1	1	2–5(3)	3–12(6)	—	P
4	1–6(2)	2,3(2)	9–25(15)	3–5(3)	2–5(3)	3–6(4)	3–9(5)	2–6(3)	1–4(3)	2–4(3)	1	1	1,2(1)	—	P
5	11–22(17)	—	14–37(25)	1–3(1)	22–42(32)	3–7(3)	3–10(6)	2–11(7)	3–8(3)	2–8(5)	4–9(6)	4–10(6)	3–9(5)	—	—
6	10–24(15)	—	1	1–4(2)	1–3(2)	23–41(31)	27–41(36)	18–40(29)	1	1	1	3–9(6)	—	1,2(1)	—
7	5–30(29)	—	18–42(32)	1–4(3)	15–45(32)	21–41(29)	23–40(32)	2–6(3)	2–6(3)	2–4(3)	2,3(2)	3–12(4)	—	1,2(1)	—
8	2–8(5)	—	14–34(28)	14–30(24)	22–41(32)	—	2,3(3)	2–4(3)	2–4(3)	2–4(3)	2–4(3)	2–9(4)	—	2–4(3)	—
9	2–9(6)	—	1	1	1	3–10(3)	2–11(6)	3–12(6)	2–12(7)	4–12(7)	3–12(8)	3–10(6)	—	1–6(3)	—
10	1–4(2)	—	1	1	1	1	1–6(3)	1	1	1	1–3(2)	2–7(5)	—	1	—
11	15–46(30)	—	1,2	1	1,2(1)	1–4(3)	1,2(1)	1–8(2)	1–3(2)	1–4(2)	1–4(2)	1–9(3)	—	1	—
12	2–6(4)	—	1	1,2(1)	1–3(2)	1–4(2)	1,2(1)	1–4(3)	2–6(3)	1–3(3)	1	1	—	1	—
13	2–7(4)	—	1–5(3)	1–9(4)	1–4(2)	4–13(7)	4–16(7)	4–12(9)	4–12(6)	4–8(5)	5–12(8)	3–8(4)	—	1	—
14	1–4(1)	—	3–14(8)	4–12(9)	—	—	1	1	1	1	1	1	1	—	—
15	1–15(2)	—	—	—	—	—	—	—	—	—	—	—	—	—	—

P = plumose

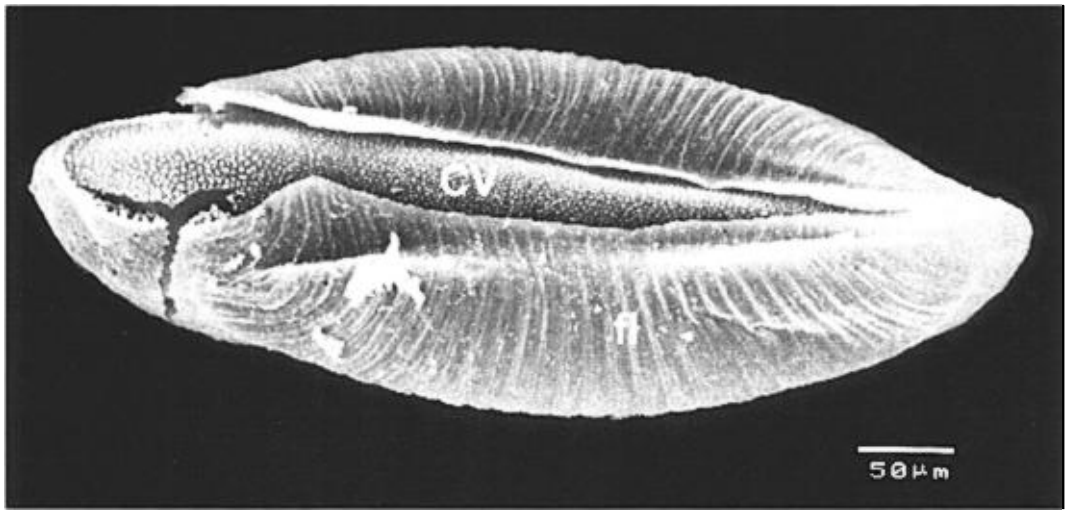

Fig 4. *Anopheles konderi*, egg. Coari, Amazonas, Brazil, dorsal surface. Scanning electron micrograph.

130 µm (114–170 µm); length 3.4 (2.4–3.8) of width. Floats moderately wide, about 0.87 (0.74–0.9) of total egg length, with approximately 36 (35–38) float ridges; float occupying nearly 0.33 of dorsal surface; deck narrow, hardly visible on posterior end in most of examined eggs but much wider on anterior end. Anterior deck enclosed by frill. Anterior end broadly rounded; posterior end somewhat pointed.

Type material.—Neotype male by present designation, with slide mounts of 1) associated larval and pupal exuviae, and 2) male genitalia, from the progeny brood of a female captured on animal bait at the type locality of *An. konderi,* data as follow: south margin of Solimões River at Coari (3°57′S, 63°12′W), State of Amazonas, Brazil, specimen 1629, 15-VIII-1998, C. Flores-Mendoza coll., deposited at Instituto Oswaldo Cruz (IOC), Rio de Janeiro, Brazil.

Material examined.—*Anopheles konderi:* a total of 763 specimens, consisting of 188 M, 285 F, 116 Pe, 116 Le, 98 MG and 25 FG, were studied, as follows: BRAZIL: State of Amazonas, Coari, Travessia, 17–23-VIII-1998, progeny brood of female captured on animal bait, C.Flores-Mendoza and F.Souza colls., 11M, 12MG, 7MPeLe, 11F, 4FG, 4FPeLe. State of Rondônia, Porto Velho, São Miguel at Madeira River (8°55′S, 64°12′W), 28-IV-1996, progeny brood of female captured on human bait, D.Lima coll., 11M, 11MG, 5MPeLe, 11F, 6FG, 6FPeLe; Candeias de Jamari, Samuel Hydroelectric Dam (8°55′S, 64°08′W), 2-V-1997, progeny brood of female captured on human bait, C.Flores-Mendoza and M.Marrelli colls., 11M, 11MG, 7MPeLe, 11F, 4FG, 4FPeLe; Costa Marques and vicinity (12°28′S 64°16′W), various dates 1989–1992, progeny broods of females captured on human bait with the following specimen numbers (BR = Brazil, collection number, (progeny brood number), all deposited in the Smithsonian Institution, National Museum of Natural History), J.B. Lima and T.A.Klein colls.: BR095(1) 3M, 1MG, 5F, 1PeLe; BR097(2) 1M, 1MG, 1PeLe; BR100(1) 1M, 1MG, 5F; BR100(2) 1M, 1MG, 5F; BR103(3) 2M, 1MG, 5F; BR103(4) 2M, 1MG, 5F; BR103(5) 2M, 2MG, 5F, 1PeLe; BR112(1) 1M, 1MG, 5F; BR112(5) 2M, 1MG, 4F; BR119(1) 2M, 1MG, 2F; BR119(2) 1M, 1MG, 5F; BR119(6) 1M, 1MG, 5F; BR120(2) 1M, 1MG, 1F; BR125(1) 1M, 1MG, 5F; BR133(2) 2M, 1MG, 5F; BR136(2) 2M, 1MG, 5F; BR144(1) 2M, 1MG, 3F;

BR144(2) 2M, 1MG, 5F; BR161(3) 2M, 1MG, 4F; BR161(5) 1M, 1MG, 5F; BR170(1) 1M, 1MG, 4F; BR170(5) 2M, 1MG, 4F; BR174(5) 4M, 1MG, 6F; BR175(4) 2M, 1MG, 6F; BR176(2) 3M, 1MG, 5F; BR176(4) 4M, 1MG, 6F; BR176(13) 4M, 1MG, 6F; BR178(4) 2M, 1MG, 8F; BR277(14) 1M, 1MG, 12PeLe; BR277(15) 1M, 1MG, 9PeLe; BR277(17) 1M, 1MG, 10PeLe; BR277(18) 1M, 1MG, 11PeLe; BR277(19) 1M, 1MG, 9PeLe; BR277(20) 1M, 1MG, 5PeLe; BR277(23) 1M, 1MG; BR289(1) 2M, 2MG; BR289(2) 1M, 1MG; BR289(3) 1M, 1MG; BR612(1) 13M, 1MG, 18F; BR612(2) 7M, 1MG, 18F; BR612(3) 11M, 1MG, 14F; BR613(1) 11M, 1MG, 18F; BR613(2) 13M, 1MG, 14F; BR644(1) 15M, 1MG, 10F. State of Acre, Senador Guiomar, Ramal Oco do Mundo (10°09′S, 67°44′W), 9–13-III-1998, progeny brood of female captured on animal bait, R.Santos coll. 3M, 3MG, 2M PeLe, 3F, 2FG, 1FPeLe; Sena Madureira, Seringal São Pedro de Icó (9°05′S, 68°45′W), 22-VIII-1998, progeny brood of female captured on animal bait, R.Santos coll., 2M, 2MG, 1MPeLe, 2F, 2FG, 2FPeLe. State of Espírito Santo, Linhares, Sooretama forest reservation (19°41′S, 39°59′W), 15–25-IV-1996, progeny brood of female captured on animal bait, C.Flores-Mendoza and C.Santos, colls., 2M, 1MG, 2F, 1FG, 1FPeLe. PERU: Loreto Departament, Yurimaguas, Munichis (05°53′S, 76°12′W), 5–10-I-1999, progeny brood of female captured on animal bait, C.Flores-Mendoza, R.Fernandez and T.Santa Cruz colls. 11M, 11MG, 6MPeLe, 11F, 11FG, 5FPeLe.

Distribution.—According to our data and the literature records, *An konderi* occurs in Brazil (states of Amazonas, Acre, Rondônia, Espírito Santo, Pará, São Paulo, Mato Grosso and Rio de Janeiro), Peru (Loreto Department) and Bolivia (Cochabamba).

Bionomics.—*Anopheles konderi* has been collected most often close to or inside forest rather than in peridomestic environments. It bites primarily outdoors, at sunset. In Coari, although *An. konderi* females were captured from sunset until 21:00h and around sunrise, the peak of biting activity was between 17:30 and 18:30h. Although it bites humans, *An. konderi* is mostly zoophilic. In Coari collections performed in a corral, 26 out of 55 anophelines caught were *An. konderi.* In Porto Velho, using human bait, only 17 *An. konderi* were captured (among 270 anophelines), whereas in Samuel it accounted for 40 specimens out of 152 anophelines caught. In Senador Guiomar, no *An. konderi* was found among 485 anophelines collected on human bait, whereas three females belonging to this species were obtained from a horse (among 110 anophelines). In Munichis, 10% of 1,207 anophelines collected using a horse-baited Shannon trap were *An. konderi*; no specimens were captured on human bait at this locality.

Larvae of *An. konderi* have most often been found in shaded or partially shaded pools, small streams, and temporary lakes formed during the flooding of rivers. These sites usually have emergent vegetation and sometimes contain muddy water rich in decomposed plant debris. In Coari, 48 and 44 out of 93 anopheline larvae collected in a small stream that received the flow of a waste drainage pipe were *An. konderi* and *An.* (*Ano.*) *mattogrossensis* Lutz & Neiva, respectively. Larvae of *An. konderi* have been found together with *An.* (*Nys.*) *nuneztovari* Gabaldon, *An.* (*Ano.*) *mediopunctatus s.l.* (Theobald), *An.* (*Nys.*) *rangeli* Gabaldon, Cova-Garcia and Lopes, *An.* (*Ano.*) *punctimacula* Dyar and Knab and *An.* (*Ano.*) *mattogrossensis* (Galvão and Damasceno 1942, Deane et al. 1948).

Medical importance.—The role of *An. konderi* in malaria transmission is unknown, primarily because females belonging to this species could not be distinguished from those of *An. oswaldoi.* Experimental infections with *Plasmodium vivax* suggested that *An. konderi* is less susceptible than *An. oswaldoi* (Marrelli et al. 1999).

Discussion

Throughout it range from Southeastern Brazil to the Amazon Valley it is possible that many literature records referring to *An. oswaldoi* are actually *An. konderi.* Precise identifications can only be verified by examination of the male genitalia. The two species are sympatric at most collection sites. However, along the Solimões and Amazon Rivers in the state of Amazonas it is our impression that either only *An. konderi* is present, or it is at least much more abundant than *An. oswaldoi.* At present only *An. oswaldoi* is reported from Venezuela, northern Colombia, Panama and Costa Rica, while only *An. konderi* has been found in Peru.

Morphological and morphometric analyses of *An. konderi* from seven localities in Brazil and Peru showed that it is a highly variable species since variation was detected between specimens from the same locality and from the same progeny brood. In females, 11 out of 13 morphometric measurements analyzed did not show statistically significant differences ($P > 0.05$). The ratios length of palpus/hindfemur ($P = 0.003$) and length of dark-scaled band on foretarsomere III/total length of tarsomere III were significantly variable ($P = 0.001$). Three out of seven morphometric measurements or ratios taken from the male genitalia were significantly different: length of parabasal seta/width of gonocoxite at base ($P = 0.001$), length of gonocoxite/width of gonocoxite at base ($P = 0.009$), width of gonocoxite taken at the widest point/width of gonocoxite at base ($P = 0.001$). The five ratios or indices evaluated in the pupa were homogeneous between populations, whereas three out of seven morphological characters and ratios analyzed in the larva were heterogeneous: length of anal papilla/length of seta 4-X ($P = 0.001$), percentage of specimens with seta 1-X born on saddle ($P = 0.035$) and type of pecten ($P = 0.037$). The eggs oviposited by *An. konderi* females from five different localities in Brazil and Peru were morphologically similar. However, the mean length and width of eggs from these localities (length = 421 μm, width = 130 μm) are smaller than those found by Lounibos et al. (1997) for specimens from Alto Linares, Bolivia (length = 520 μm; width = 197 μm).

Anopheles konderi is closely related to *An. oswaldoi* and therefore will key out with *An. oswaldoi* in the keys to females and larvae in the most recent revisions of the Albimanus Section of *Anopheles* subgenus *Nyssorhynchus* (Faran 1980, Faran and Linthicum 1981). No diagnostic morphological or morphometric differences were found between the pupae or eggs of these species. However, they are readily distinguished by the shape of the aedeagus. In *An. oswaldoi,* the aedeagus is ovate and sclerotized at the apex, the length of the apex of the aedeagus is about 1.2 (0.8–2.1) of the width, while in *An. konderi* the aedeagus is weakly rounded at apex, the length of apex of aedeagus is about 0.4 (0.3–0.6) of width, and the apical aedeagal sclerite is narrow and curved into elbow-like lateral projections. Males of *An. konderi* key out to *An. evansae* Brèthes in the key for male genitalia in Faran and Linthicum (1981), but *An. konderi* can be distinguished from *An. evansae,* as well as from the other *Nyssorhynchus* of the Albimanus Section, by the shape of the aedeagus. The morphological and morphometric characters of the females and larvae of these species are also very similar. Statistical analysis showed some morphometric differences between females of these species: in *An. oswaldoi* foretarsomere 2 is dark-scaled on 0.6 (0.4–0.8) ± 0.1 (while it is 0.7 [0.5–0.9] ± 0.09 in *An. konderi,* $P < 0.0001$), hindtarsomere 2 dark-scaled on 0.11 (0.08–0.16) ± 0.026 (while it is 0.14 [0.08–0.20] ± 0.036 in *An. konderi,* $P < 0.0001$), subcostal pale spot 0.3 (0 003–0.5) ± 0.1 of sector dark (0.2 [0–0.4] ± 0.09 in *An. konderi,* $P < 0.0001$), preapical pale 0.4 (0.2–1.0) ± 0.2 of preapical dark (0.3 [(0–0.5] ± 0.09 in *An. konderi,* $P = 0.009$), acces-

sory sector dark present in 82.4% (± 0.921, $P = 0.65$) of specimens examined (around 60% in *An. konderi*).

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